

A Bird Census and Some Recent Observations on Birds on Great Island, Three Kings Group

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Abstract.

Thirteen counts of land-birds on a ten-acre square quadrat on Great Island, Three Kings group, between January 2nd and 8th, 1953, gave an average of 62 birds per count (58% were bellbirds). Different weather conditions, observer-error, time of day and bird movements caused the counts to vary between 39 and 90 birds, the larger counts being characterised by a higher proportion of sight records. Although bird density varied in different parts of the quadrat, the species retained their relative order of abundance which was similar to that in other parts of the island. The breeding population was assessed at 28 pairs (11 species).

Part II contains miscellaneous observations on the breeding and feeding habits of 22 species of land and sea birds, with special reference to the effect of vegetation changes which followed the removal of wild goats in 1946. The increased ground cover provides more quail food, but reduces the area inhabited by pipits and restricts the extent of gull colonies. Conditions are improved for burrowing petrels, except where the vegetation is especially dense.

PART I. CENSUS.

A visit was arranged by the Auckland Museum to Great Island, of the Three Kings group, between 29th December, 1952, and 9th January, 1953. The main purpose of this paper is to record some quantitative observations made on the land birds during this visit. With the present data as a basis, it is hoped that future observations will determine the nature and extent of any changes in the abundance of birds. Such changes are to be expected because the removal of all the goats from the island in 1946 has already resulted in obvious changes in the vegetation (Baylis, 1948, 1951; Turbott, 1948; Holdsworth, 1951). For an account of the history and other features of the island at the time of the destruction of the goats see papers in *Records of the Auckland Institute and Museum*, Vol. 3, Nos. 4 & 5 (1948).

Modification of the vegetation was brought about by early Maori occupation, followed by the influence of goats. The forest consisted, in 1946, of a fairly uniform canopy of kanuka (*Leptospermum ericoides*), and as a result of the activities of goats the open forest floor was clothed for the most part only in sparse sedges and turf. In some localities, a few climax forest remnants gave variety to the otherwise uniform vegetation. Obvious changes since 1946 have been the appearance in many places of an undergrowth of young forest trees (Fig. 1) and of the vigorous herbaceous plant *Colensoa physaloides*, and the development of the ground layer in nearly all parts of the forest into a dense cover of matted sedges, grasses and herbs up to two feet in

height (Fig. 2). This ground cover is so dense that it has checked the re-establishment of seedlings of kanuka, which even in the presence of goats had been able to grow beneath openings in the canopy (Baylis, 1951).

Unfortunately, census work was not possible in 1946 when the goats were destroyed nor during the period when the earliest stages of regeneration were taking place. The discussion of the status of land birds in relation to the effects of the goat population (Turbott, 1948) was thus based on rough estimates made by P. C. Bull (November-December, 1945) and E. G. Turbott (April-May, 1946), respectively. The bellbird* was the most abundant species, the remainder being represented only by small populations. The pipit was placed next in order of abundance, although considerably below the bellbird in numbers. Pipits and brown quail were observed feeding on the open forest floor.

In some parts of the island the new undergrowth of young trees and shrubs has provided additional cover for forest birds, and the much denser ground cover may be altering the status of at least two species. The pipit is now apparently restricted to the more open parts of the island—rocky outcrops in the forest, grassland and coastal rocks—and may thus have become less abundant since 1945-46. The brown quail was apparently not reduced in numbers, but it evidently now had difficulty in rising from the ground vegetation when flushed, sometimes even flying off partly entangled in the long seed heads of sedge (*Carex testacea*).

Although these observations suggest that some slight changes had occurred in the bird community during the period 1946-53, it is believed that the present study is early enough to provide a useful reference point from which to measure the larger changes which may occur in the future. Various additional observations made on the birds of the island during the present visit are included in Part II, but for a full account of the birds reference should be made to the earlier papers by Turbott and Buddle (1948) and Turbott (1951).

Methods.

Counts were made of the birds seen while walking over a quadrat measuring 220 yards square, i.e., ten acres in area. The south-east corner of this quadrat was also the south-east corner of the permanent Vegetation Quadrat I set up by Turbott in 1946, and full directions for locating this point have already been published (Turbott, 1948). The second permanent Vegetation Quadrat (No. II) is located towards the centre of the census quadrat. Additional topographical detail is available on the map of Great Island prepared by Battey (1951). The larger, new census quadrat slopes towards the south-east and its lower part includes two small valleys containing remnants of the original climax forest, but except for these and two rocky outcrops, the area is uniformly covered by kanuka forest (Fig. 2), which becomes increasingly stunted towards the higher north-western portion of the quadrat where it is more exposed to the wind. Six parallel counting lines, each

* Scientific names of birds are listed in Part II.

40 yards apart, were marked with light cord before the counts began, and each of these was divided into upper and lower halves with respect to the slope of the quadrat. The counts were made by the observer moving at a slow walking pace along the lines and recording all birds seen or heard at an estimated distance of up to 20 yards on either side of lines 2 to 6, but on only one side of line 1 (in order to cover the correct area).

In all, 13 counts were made over a period of seven days, and were carried out at different times of the day and under various weather conditions. On two counts the two observers walked together, counting separately, but for the remaining counts each worked alone. Each count occupied about two hours, and a separate record was made of the numbers of each species seen or heard in each half of the six counting lines. These data have been summarised in the present paper. Full details of each count are deposited at the Auckland Museum.

A limited number of traverses and observation periods carried out over other parts of the island helped to indicate the extent to which the relative abundance of species on the census quadrat was typical of the island as a whole. The traverses consisted merely of a record of the number of individuals of each species seen or heard while walking over the island in connection with other work. The observation periods were five-minute intervals, during which the observer tried to see or hear as many species as possible from a fixed point, each species being recorded only once per period. The frequency with which a species was recorded in a series of observation periods gives some measure of its abundance and conspicuousness. It has an advantage over traverses of the above type in that the observer gives his full attention to watching and listening to birds, so that the conspicuousness factor is somewhat reduced except for song.

The quadrat census, supplemented by figures for relative abundance (traverses and observation periods) on other parts of the island, has the advantage of being readily repeated, and a future census could be carried out on a comparatively brief visit, especially as the quadrat is situated near the usual landing place on the island. As two of the permanent vegetation quadrats are located within the census quadrat, fairly detailed correlation of the status of the land birds with changes in the vegetation may also be possible on the area.

Results.

The results of the 13 counts are summarised in Table 1, and contain a total of 805 records or an average of 62 individual birds per count. Of the 11 species recorded, bellbirds accounted for some 58% of the total records, followed by parakeets and quail (about 9% each) and then blackbirds at some 5%. There is considerable variation between the figures obtained during the different counts and the causes of this must now be examined.

Counts 1 and 2 were made with the observers walking together but counting independently, and the results show fairly close agreement. A similar result was obtained from counts 9 and 10, which were done in the same way. Since each pair of these counts was carried out simultaneously, the slight differences obtained are the result of observer-error. Decisions involving whether or not a given bird has been counted already

TABLE 1.

No. of Count	Date	Time: hrs.	Weather	Observer	(a)		(b)	
					No.	No.	No.	No.
1	2/1/53	1600-1900	Overcast, N. breeze	E.G.T.	48	(60)	(21)	6
2	2/1/53	1600-1900	Overcast, N. breeze	P.C.B.	45	(67)	(27)	7
3	3/1/53	1000-1200	Overcast, N. breeze	E.G.T.	35	(46)	(23)	7
4	3/1/53	1100-1300	Overcast, N. breeze	P.C.B.	41	(51)	(24)	11
5	3/1/53	1600-1800	Cloud lifting, breeze dropping	E.G.T.	34	(59)	(6)	6
6	4/1/53	0700-0900	Calm and warm	P.C.B.	58	(71)	(29)	6
7	4/1/53	1700-1900	Drizzle and rising wind	E.G.T.	33	(36)	(15)	—
8	5/1/53	1500-1700	Strong W. breeze, drizzle	P.C.B.	34	(56)	(26)	5
9	6/1/53	0700-0900	Strong S.E. breeze	E.G.T.	22	(32)	(27)	2
10	6/1/53	0700-0900	Strong S.E. breeze	P.C.B.	28	(43)	(18)	3
11	6/1/53	1600-1800	Strong S.E. breeze	E.G.T.	29	(28)	(21)	7
12	7/1/53	1500-1700	Warm & sunny, S.E. breeze	P.C.B.	30	(23)	(33)	3
13	8/1/53	1000-1200	Hot, S.E. breeze	P.C.B.	31	(42)	(32)	11
Total records		468	(50)	(24)	74	72	43	10
Each species as % of total records		58	—	—	9	9	5	2
Total of counts 1-6		261	(60)	(23)	43	47	27	7
Total of counts 8-13		174	(38)	(27)	31	24	12	3
Mean of six highest counts for each sp.		44	—	—	8	8	5	1

Note—

(a) : Per cent. bellbirds recorded by sight.

(b) : Per cent. bellbirds recorded in upper half of quadrat.

are probably more important in causing observer-error than are acuteness of sight and hearing. The two present observers compared notes after the counts and also had worked together previously; thus the results obtained by a completely independent observer might show greater variation.

The frequent presence of observers in the quadrat might be expected to disturb the birds and cause some of them to leave. To check this point, counts 3 and 4 were carried out with one observer walking one hour behind the other, but in this instance the later observer actually recorded more birds than the first one—a result probably attributable to observer-error. If birds were being disturbed one might expect to record fewer birds on the later counts. The number of birds recorded during the first six counts was compared with that during the last six (Table 1), and it was found that for every species except morepork owls, the later counts were very much smaller than the earlier ones. However, this may be largely due to less favourable weather conditions. (The lower records for moreporks during the earlier counts were due to the fact that their regular roosting places were not all known at this time, but once found they were more likely to be recorded on subsequent counts.) Weather conditions, especially wind, undoubtedly played an important part in causing variations in the different counts. The quadrat is completely sheltered from northerly winds, which prevailed during counts 1 to 5, which were all fairly large. Count 6, the largest, was carried out under conditions of calm and warmth. The remaining counts were low and were carried out in drizzle (7 and 8) or with a south-east wind (9-13)—the quadrat being particularly exposed to this direction. The total for count 6 (calm) is over twice that for count 10 (strong S.E. wind), although both counts were done by the same observer at the same time of day. For the remaining counts it is difficult to separate the effect of weather from that of time of day, but the latter is generally considered to be important (Colquhoun, 1940a).

However, the present counts probably provide a fair indication of the amount of variation to be expected in counts of the bird population which existed on the quadrat at that time; the last four counts did not increase the variation established by the previous nine.

When birds were heard an attempt was made to sight them if this could be done fairly quickly and without causing too much disturbance. Otherwise a single bird was recorded unless there was reason for suspecting more, but counting from sound is difficult in a species such as the bellbird, in which the song sometimes has a ventriloquial effect. The two observers varied in the proportion of birds they recorded by sight and sound respectively. For bellbirds (the only species with numbers allowing individual analysis), 53% of one observer's total records were by sight, but for the other this figure was only 42%, and statistical tests indicate that this difference is no greater than could be accounted for by chance ($p = 0.15$). The percentage of sight records of bellbirds on each count varied between 23% and 71% for one observer, and 28% and 60% for the other. When both observers did their counts at the same time the proportion of bellbirds seen by each was similar. There is evidence of a direct relationship between the proportion of sight records and the total number of bellbirds recorded on each count. For instance, count 6 produced both the largest number of bellbird

records (58) and the highest proportion of sight records (71%), while count 9 (carried out at the same time of day) produced the smallest number of bellbirds (22) and a low proportion of sight records (32%). The results of other counts showed a similar trend. Thus, in addition to the observer effect, the census showed that weather and time of day are important in determining the relative frequency of records by sight and sound respectively. A high proportion of sight records suggests a high degree of bird activity, and thus conspicuousness, leading to a high total count. Unfavourable weather conditions such as wind and rain result in a small total count, less activity, reduced conspicuousness and a small proportion of sight records. Unfavourable weather conditions, especially wind, reduce vocal activity in blackbirds (Colquhoun, 1939), but the present work suggests that for bellbirds flight activity is affected first, then song, and call notes last of all.

There is evidence that birds were not evenly distributed over the census quadrat. When the total number of bellbirds recorded in the upper halves of the 6 counting lines was compared with that in the lower ones (Table 1) it was found that the former produced only 24% of the total bellbird records. For the individual counts this figure varied between 6% and 33%. If birds were evenly distributed over the quadrat the numbers found in each half should be approximately the same, but statistical tests of the present figures show that in 12 of the 13 counts the differences found were greater than could be accounted for by chance ($p = 0.03$). The concentration of bellbirds in the lower part of the quadrat could be due to its more sheltered position, to the taller trees or to the more diverse vegetation, and thus food, provided by the remnants of the original forest.

Some idea of the relative frequency of species on other parts of the island was obtained from the traverses and observation periods, and

TABLE 2.

	Traverses				Each Species as % of:		
	T1.	T2.	T3.	Total T1-3.	183 Traverse Records	805 Quadrat Census Records	22 Observation Periods.
Bellbird	14	24	38	76	42	58	100
Parakeet	7	7	27	41	22	9	55
Quail	9	4	10	23	13	9	36
Blackbird	4		7	11	6	5	23
Kingfisher	1	3	4	8	3	2	23
Starling	1		5	6	3	3	9
Chaffinch	2		4	6	3	3	9
Fantail	2		1	3	2	4	5
Pipit	2	1	1	4	2	2	5
Thrush	1	1	1	3	2	—	—
Harrier			1	1	1	—	—
Long-tailed cuckoo			1	1	1	—	—
Morepork			—	—		4	—
Banded Rail			—	—		1	5
Total	43	40	100	183	100	100	—

Note.—Traverses Nos. 1 and 2 were done by E.G.T. and No. 3 by P.C.B.

Traverse No. 3 occupied over twice the time and distance of the others.

Table 2 compares these results with those obtained from the quadrat counts. It is evident that the first four species retain their order of abundance irrespective of the method of assessment. Since a census

count is only a very careful traverse count over a known area the two methods should give the same order of abundance if carried out in the one locality under similar conditions of season and weather. The results obtained (Table 2) are similar even though carried out in different localities, so it seems reasonable to assume that the land bird community of the quadrat was typical of the island as a whole, at least as regards the relative abundance of the various species. Some land birds present on Great Island were not recorded on the quadrat, but the missing species are numerically unimportant.

Discussion.

The present work was designed primarily to determine the amount of variation which might be expected in a series of counts of an approximately stable bird population. Thus a future observer, using the present methods on the same quadrat and at the same time of the year, will have some basis for judging whether or not his counts reflect a real change in the size or composition of the bird community. As a secondary consideration it was hoped to obtain a reasonable estimate of the actual number of individuals of each species living on the ten acres so that comparisons could be made with work in other areas. To this end it is now necessary to consider the meaning of the various bird counts made on the quadrat.

The several counts yielded rather different values, and this is accounted for by observer-error (double counting and under counting), and probably by movements of birds out of the area (human disturbance) or into it (e.g., to mob moreporks), and by changes in the conspicuousness of the birds themselves (largely influenced by time of day and weather conditions). Observer-error and movements of birds can either increase or reduce the count, and may act together or against each other. Their total effect cannot be accurately assessed from the data available, and they are perhaps best allowed for by taking the mean value of all the counts. Changes in conspicuousness, however, can only make the count too low, and from this point of view the highest count should be the most accurate. In view of these considerations, and from the experience gained while working in the quadrat, it was felt that the mean values for the six highest counts (Table 1) provided the best indication of the abundance of various species.

The importance of relative conspicuousness in census work on bird communities has been stressed by Colquhoun (1940b), and this must also be considered in the present work. For instance, bellbirds are highly conspicuous by virtue of their song and noisy flight, while rails are seldom heard by day and less often seen, since they live under the dense cover of the tall sedges and rarely fly even if disturbed. Parakeets with their bright colours in full sunlight, and harsh flight calls, are on occasions perhaps even more conspicuous than bellbirds, although sometimes silent and easily overlooked. While bellbirds could usually be seen at distances up to 20 yards on either side of the counting line, quail would flush only when the observer passed within a few feet of them, although their call notes sometimes allowed identification at much greater distances. Thus if it be agreed that the mean values obtained for the six highest counts provide a reasonable indication of the abundance of

such birds as bellbirds and parakeets, then the comparable values for banded rail and quail are almost certainly too low. How much too low is at present unknown.

The birds counted during the census included both adults and young birds of the year. It was not possible to count these two groups separately because this would have necessitated obtaining close views of every individual and such an attempt would cause further disturbance and add greatly to the time occupied by the count. However, for purposes of comparison with other work it is necessary to convert the present figures into terms of breeding pairs. The available information does not allow this to be done accurately, but if an approximation is to be made it is best done by the observers who did the counts. In doing so they have been guided by their records of young birds actually seen and by general impressions obtained while working in the quadrat. With this in mind, the mean values for the six highest counts (Table 1) are now discussed species by species.

Bellbird. It is considered that approximately half the birds seen were young of the year. The mean value of 44 birds thus comes to represent some 11 pairs of breeding adults.

Parakeet. No young birds were seen on the island, and the only nest found contained eggs. There was no evidence that any parakeets lived exclusively on the quadrat, which provided few suitable nesting places. The birds seen feeding there probably had nests in the cliff face below. An average of four pairs of parakeets were recorded feeding on the quadrat, but the numerous birds flying about overhead made counting difficult, and three pairs is thought to be a more accurate figure.

Quail. No young were seen but a nest of eggs was found near the camp. The average figure for the counts suggests that four pairs lived on the quadrat.

Blackbird. This species was frequently heard but rarely seen. Comparison may be made with a population of blackbirds studied in Lower Hutt, where, by December, 50% consisted of young birds of the year (Bull, 1953). On this basis the Great Island quadrat would have supported one pair, but from past experience of the retiring habits of this species when living far from human influence it is thought that two pairs is a more likely figure.

Kingfisher. Two pairs of adults were seen, but as both were on the boundaries of the quadrat the population is assessed at one pair.

Starling. At the time when the census was made most starlings were in flocks, including a few young birds of the year. Single birds and small parties were also frequently seen—perhaps being temporarily detached from the main flock or not yet having joined it. These odd birds were the ones recorded during the census counts. The counts suggest a little less than one pair of adult birds per ten acres.

Chaffinch. Two pairs situated as for kingfishers, so that the area probably supported only one pair.

Fantail. Several of the birds seen were young of the year, and one pair is believed to be the breeding population.

Pipit. The breeding population is estimated at one pair.

Morepork. Two pairs of adult birds were found—one in each valley. One pair had flying young.

Banded Rail. At least one pair was present.

The above estimates give a total of 28 pairs of breeding adults and include 11 different species. Converting this to a 100-acre unit the figure becomes 280 pairs or 560 individuals. In a census on Taranga (Hen Island) Turbott (1940) found a population of 728 breeding birds (17 species) per 100 acres of forest habitat and 467 birds (8 species) on a previously-burned area then in mixed thicket and shrubs. The quadrat on Great Island cannot be taken as typical of the island as a whole, since it contains a disproportionately large amount of remnant forest and sheltered valley habitat. The upper half of the quadrat is more typical, and considering this portion alone the bird density was only 440 per hundred acres. The relatively low density of birds on Great Island as compared with Hen Island is probably related to the modified vegetation, which, lacking variety, may not provide adequate food throughout the year.

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PART II. GENERAL OBSERVATIONS.

Diving petrel. *Pelecanoides urinatrix* (Gm.). All the burrows examined were empty, although a number of dried-up remains of adults and fully fledged young were found on the steep slopes above South East Bay, and the south-western cove.

The slopes above South East Bay, formerly free of scrub, and kept relatively bare by goats, now have a dense ground vegetation which may have an effect upon this and possibly other petrels. Some burrows are now covered by dense sedges, grasses and herbaceous plants, which probably make them difficult of access. A twined mass of the trailing stems of native cucumber (*Sicyos angulata*) covers much of this area, and several dead diving petrels, including a fledgling with shreds of down still attached, were found entangled in the cucumber stems. This type of vegetation may later be replaced by mixed scrub, which would bring about a reduction in the ground cover and would be more favourable for petrels.

It should be noted that the effect of the goat population is still reflected in the distribution of burrows of petrels of various species. These birds were formerly unable to breed on most of the inland portions of the island where the hard soil, resulting from the lack of plant cover and trampling by goats, was unsuitable for burrowing (Turbott, 1948). The influence of the later stages of forest regeneration upon the distribution of petrels will thus be of considerable interest.

Fluttering shearwater. *Puffinus gavia* (Forst.). The young varied in age in different burrows from downy chicks with the first feathers showing to fully fledged young with a few wisps of down on the lower breast. The burrows are thickly scattered over the seaward slopes wherever the soil is comparatively loose, as well as under low scrub along the cliff-tops. In some places, e.g., on the saddle between North West and South East Bays, tunnels were found penetrating dense sedge as though the birds had been trying to become established there recently, but unless the soil was loose no proper burrows had been formed. Burrows were abundant on the slopes above South East Bay, this species apparently being less affected by the dense ground vegetation in this area than the diving petrel. It seemed probable, on the basis of our previous observations, that there had been some increase since 1945-46 in the numbers of burrows of this species. This was observed mainly on seaward slopes which had originally been much trampled by goats. Apart from the attempts already mentioned to form burrows amongst dense sedges on flatter areas adjacent to the seaward slopes, burrows are situated inland only in a few places in cavities among rocks. However, a burrow containing a well-grown chick was noted near the camp in Castaway Valley in a flat situation in fairly soft ground under the kanuka forest (the same burrow was in occupation during the preceding visit by an Auckland Museum party, 10th-15th January, 1951). This burrow ran underground only a few inches below the surface, beneath a deposit of kanuka twigs and camp debris; it is not known whether it had been formed in 1945-46, but it is possible that more burrows will be found in situations of this type now that there is no further trampling by goats.

The first fluttering shearwaters were heard at night shortly before 9 o'clock, but the time of arrival and the numbers heard in the air varied considerably under different weather conditions. On clear nights with moonlight the calls began later, and few birds were heard, but there was much calling on misty or cloudy nights. The chirping note of the chicks in burrows was heard as early as 8.45 on a cloudy night with some rain. The adults of the burrow near the camp were ringed*. No. 11302 (sex unknown) was ringed on arrival at the burrow at 10.30 p.m. on 2nd January, and it returned to the burrow at almost the same time on the following night (3rd). On 4th January its mate visited the burrow, also at about 10.30 p.m., and was ringed, No. 11303. On the last evening (8th) both adults were observed sitting together outside the burrow, the first to arrive being No. 11302, at 9.50 p.m. When one of the adults was being handled on arrival, it disgorged a quantity of small shrimp-like crustaceans which have been identified by Mr. R. K. Dell, of Dominion Museum, Wellington, as the common Australian and New Zealand Euphausiid *Nyctiphanes australis* G.O. Sars.† (See also identification of the same food organism cast up by young red-billed gulls.)

Grey-faced petrel. *Pterodroma macroptera* (Smith). This early breeding petrel was apparently absent during the visit. It was commonly observed in April-May, 1946 (see Turbott and Buddle, 1948).

Pterodroma sp. The "ti-ti" or "kek-kek" call characteristic of certain gadfly petrels (*P. cooki*, *P. inexpectata*, *P. pycrofti*) was heard at about 9 p.m. above Castaway Valley and from the cliff-tops to the west of the depot during this visit. The same call was heard by P.C.B. in November-December, 1945, at about the same point (not to the east of the depot as stated by Turbott and Buddle, 1948). A search for burrows was made in likely areas without success, but this as yet unidentified *Pterodroma* evidently breeds on Great Island in small numbers.

White-faced storm petrel. *Pelagodroma marina* (Lath.). A second call was noted several times in the same locality as the above, and was identified tentatively as that of the present species. Previous evidence suggesting that it may breed on the island was obtained in 1945, when remains were found in a morepork's nest.

* For records of ringing on this visit see Bull, P. C., 1953: "Ringing Operations. Summary for the Year Ended 31 March, 1953." *Notornis*, 5, 138-141. Both of the above *P. gavia* were ringed on the left leg.

† We are indebted to Mr. Dell for his identification of the material and for referring us to the following literature on *N. australis*. It was taken, often in very large numbers, in plankton obtained during July-September, 1911, by the British Antarctic ("Terra Nova") Expedition off the Three Kings Islands (see Tattersall, W. M., 1924: "Euphausiacea," *Brit. Ant. ("Terra Nova") Exp., 1910, Nat. Hist. Rep. Zool.*, VIII; Crustacea, Pt. VIII, 1-36). Together with other species which swarm during their breeding period, it is probably an important source of food for schooling fish and sea birds, according to Sheard (Sheard, K., 1953: "Taxonomy, Distribution and Development of the Euphausiacea (Crustacea)," *B.A.N.Z. Ant. Res. Exp., 1929-1931, Rep.*, B, VIII, 1-72). *N. australis* is confined to neritic waters of Australia and New Zealand of the cooler sub-tropical zone. Most of the specimens sent to Mr. Dell were adult.

Black shag. *Phalacrocorax carbo* (L.). A single bird almost certainly of this species, which has not been recorded previously from the Three Kings group, was seen at some distance in North West Bay, where it was fishing close inshore.

Red-billed gull. *Larus novaehollandiae* Steph. Immediately after the goats were destroyed the large colonies above South East Bay appear to have expanded considerably on the upper portion of the slopes (Turbott, 1948: footnote), possibly because disturbance by goats had previously restricted the colonies to the lower slopes. The colonies in South East Bay are now reduced to a few isolated groups on bare, rocky outcrops not far above sea level, and this may be due to the dense ground vegetation mentioned above.

There is also a large colony, on slopes previously accessible to goats, above the S.W. cove, but in this area the ground vegetation is much less rank. The slopes were formerly to a large extent bare, and the area is more exposed to constant strong winds than above South East Bay. However, a considerable amount of regeneration of ground vegetation has taken place, especially on the lower portion occupied by the gulls; this bears lush mats of *Disphyma australe*, *Dichondra repens*, *Chenopodium triandrum* and *Salicornia australis*, amongst which grow grasses (*Polypogon monspeliensis* and *Poa anceps*), and herbs (*Senecio lautus* and *Gnaphalium luteo-album*). There is also a sprinkling of low bushes of ngaio (*Myoporum laetum*), taupata (*Coprosma repens*), *Hebe insularis*, and tall sedge, etc. (*Cyperus ustulatus*, *Arundo kakaho* and *Phormium*). As the ground vegetation in this area is probably increasing, it will be interesting to compare the extent of the colony as shown by photographs on later visits. It was also noted that the presence of rank vegetation in the colonies may endanger nestlings. Two young chicks were found beside one nest entangled in the soft, drooping grass *Poa anceps*; one chick was already dead and the other was firmly held by one leg, which had evidently been dislocated by the chick's struggles to escape.

Further large colonies which were also examined cover the steep slopes above Tasman Bay, and extend into the low scrub of taupata (*Coprosma repens*) at some points on the cliff-tops. The slopes to the south of the Tasman Stream, which falls into the head of the Bay, are clothed in dense iceplant (*Disphyma australe*), but the greater part of the nesting birds are concentrated on the rocky ledges near sea-level or on the steeper portions of the cliffs, only a few nesting on the slopes in hollows in the iceplant.

From observations during the present visit on the above colonies it thus seems probable that, with the increase of ground vegetation on the less steep seaward slopes of the island, colonies of this species are likely to be restricted to cliff ledges and the more rocky portions of the slopes. It seems probable that there was at first a tendency for the colonies to expand in certain areas on the seaward slopes after the destruction of the goats. However, this was only temporary owing to encroachment by the vigorously regenerating vegetation.

Most of the eggs were just hatching at the end of December, but there were a few older chicks and fledglings, and at least one almost ready to fly. The following observations were made on clutch size and hatching dates in various colonies on different days:—

S.W. cove, 30th December.—Of 134 nests with contents 76 had one egg or chick and 58 had two eggs, two chicks or an egg and a chick.

Of 135 nests, 57 had one egg, 27 had two eggs, nine had one chick, 20 had two chicks and 22 had an egg and a chick. (There were also a few empty nests and these were not counted. One-egg clutches may include some in which one egg had hatched and the chick left. Also, when only one chick was present, another might have been hiding nearby.) (P.C.B.).

Tasman Bay, 30th December.—Of 119 nests on the north side of the stream outflow 48 had one egg, 33 had two eggs, 17 had one chick, 11 had two chicks and 10 had one chick and one egg.

Of seven nests to the south of the stream outflow five contained one egg, one two eggs and one a chick. (P.C.B.)

Tasman Bay, 7th January.—Of 101 nests on the lower slopes to the south of the stream 23 had one egg, 10 had two eggs, 11 had one chick, 14 had two chicks, two had three chicks. There were six with a chick and an egg and another with two chicks and one egg; 34 nests were empty. (Breeding was more advanced here than in the colony above the S.W. cove, a proportion of the chicks which had left the nest showing scapulars and wing quills through the down, and several being at an advanced stage of fledging. The most advanced was fully fledged, with only wisps of down showing; wings and tail were not yet fully grown, but this chick was not far from the flying stage.) (E.G.T.)

South East Bay, 3rd January.—Of 33 nests, just above sea level, 18 were empty, seven contained one egg, five had two eggs, one had one young and two had two young.

Of 43 nests at the W. end of the Bay (below Castaway Stream) 13 were empty, eight contained one egg, six had two eggs, five had one young, 10 had two young and one had one chick and an egg.

(Many of the empty nests had probably been deserted by the young soon after hatching.) (P.C.B.)

Ringling was carried out at the Tasman Bay colony on 8th January by E.G.T. The 49 young birds ringed were fledglings, and this figure was probably nearly the total of young which were of suitable age in the colony. Two adults were also caught in the colony and ringed.

An additional 15 adult birds were caught and ringed at the camp in Castaway Valley where they came for scraps. (See ringling records, quoted above: Bull, 1953.)

These birds, which came about the camp when scraps were put out towards the end of the visit, seemed to stay about constantly, and were thought to be "unemployed" birds. Other such groups of apparently unoccupied birds were present on the shore, e.g., at the head of North West Bay.

Red-billed gulls feed in characteristic "swirls" of birds in the waters surrounding the Three Kings group, generally associating with fluttering shearwaters (*Puffinus gavia*). A constant passage of birds

may be observed from the breeding colonies to these feeding groups at varying distances offshore, and the groups frequently change position over changing concentrations of food organisms.*

Some of the recently-fed chicks regurgitated pink shrimp-like crustaceans identified by Mr. R. K. Dell as *Nyctiphanes australis*, the same species as that taken from an adult fluttering shearwater. The chicks appear to be fed mainly on plankton, and there is further evidence of this in the mainly reddish, paste-like droppings of both adults and young.

Notes on gulls feeding on insects over forest on Great Island.—Observations have appeared in a previous paper (Turbott, 1951) on the capture of cicadas by red-billed gulls, and it was suggested that as gulls would otherwise only pass occasionally over the forest, this habit would explain visits by gulls to all parts of the island. This made it possible to account for the transport of seeds of puka (*Meryta Sinclairii*) which had been eaten by the gulls, into various parts of the forest. On the present visit further observations were made, and some additions and corrections to the above discussion are now required. Observation of gulls passing across the island, especially in the area between Tasman Bay and the S.W. cove, indicated that there was a considerable passage of gulls between these points, which might have included gulls passing across the island to join feeding "swirls" at various points offshore, and probably also gulls from the south-western coast attracted to the fresh-water pool above Tasman Falls, where large numbers bathed regularly. The gulls frequently followed an erratic course in order to take advantage of variations in the air currents, and the routes taken thus varied considerably, so that an individual bird might pass over a fairly wide area. A similar regular passage of gulls was observed between North West and South East Bays, the birds crossing the narrow saddle at a low altitude and gliding down to sea level.

The present visit (29th December-9th January) was made approximately a fortnight earlier than the visit in 1951 (10th-15th January), and, possibly for this reason, few cicadas† were heard at first, although the numbers later increased considerably. Gulls were again observed swooping down to capture cicadas above the canopy.

* Sheard in a discussion of the schooling aggregation and behaviour of certain Australian fishes based upon stomach contents states that schooling obviously depended "at first or second remove, on the swarming of crustacean species for breeding purposes, as well as on swarms of their larvae, either as they became concentrated in local rips and eddies, or as they were released in floods during brief, mass hatching periods." The feeding behaviour of sea birds is evidently similarly influenced by surface concentrations of the food organisms. (See Sheard, K., 1953: *B.A.N.Z. Ant. Res. Exp., 1929-1931, Rep.*, B, VIII, 1-72.) Mr. R. K. Dell has kindly commented further (*in litt.*) on the feeding grounds for sea birds off the Three Kings Islands, and suggests that, in addition to upwelling on quite a large scale off the islands, there is probably minor upwelling, due to sudden changes in the bottom topography. Such areas of minor upwelling, e.g., off promontories, are known to encourage concentrations of feeding sea birds because the food organisms are carried to the surface.

† *Melampsalta cingulata*.

On this visit, observations were also made on the interesting relationship between gulls, hovering over the canopy to obtain cicadas, and one or more large flocks of starlings. The latter could be seen moving fairly rapidly through the open kanuka forest, and at the same time a flock of 30-40 gulls hovered over the canopy following the course taken by the starlings. Close observation by E.G.T. of a flock of starlings in Tasman Valley showed that they were feeding actively at all levels from the ground layer to the canopy, and it was noted that cicadas were several times disturbed by the flock. Another member of the party, Mr. J. S. Edwards, watched the flock of starlings at close quarters, and saw the birds feeding on top of the canopy. Mr. Edwards suggested that the starlings were probably taking large numbers of the abundant bronze beetle (*Eucolaspis brunneus*). He saw a cicada caught by a gull in mid-air, and in other cases gulls chased cicadas which had been disturbed but failed to catch them. While the gulls seemed to be interested chiefly in the relatively large cicadas, the bronze beetle was also possibly taken.

Also of interest in relation to this habit of the gulls is the observation that a small black bee† common on the heavily flowering kanuka was eaten in large numbers. This was first suggested by the discovery of gull castings containing the remains of bees on a rock above Castaway Valley. Gulls were occasionally seen apparently attempting to capture the bees above the kanuka canopy, and it was found later that bees were captured at the burrow entrance on the cliff-tops at the head of North West Bay, where the bees form a large colony in the bare clay. The gulls were often seen here running about and catching the bees as they emerged from the burrows, and fresh castings consisting entirely of remains of the bees were found nearby.

It seems clear from these observations that the insects mentioned above form a fairly important supplementary food, and that this habit serves to draw numbers of gulls to the forest canopy. On the eastern portion of the island, gulls were also observed in association with starlings in the neighbourhood of the census quadrat.

It was noted also that the gulls called while hunting in flocks over the canopy, just as in flocks feeding at sea on plankton, the behaviour in both situations forming a fairly close parallel.

Banded rail. *Rallus philippensis* L. Observed on the census area. One was also seen in Tasman Valley (Edwards).

Brown quail. *Synoicus* sp. A nest containing six eggs was found near the depot, Castaway Valley. Specimens were collected under permit to assist in determining the identity of this form. The following analyses of the stomach contents of the four specimens obtained, and of three obtained in 1946, was kindly carried out for us by Miss Ruth Mason, Botany Division, D.S.I.R.:

(a) Collected in May, 1946:

- (1) seeds of: *Carex testacea* (sedge).
- (2) seeds of: *Carex testacea*, mostly; *Carex virgata*, a few.
- (3) no identifiable vegetable material; much animal material.

† Specimens of the bee obtained on the island have not yet been identified.

(b) Collected in January, 1953:

- (1) seeds of: *Carex testacea*, the most abundant; *Solanum nigrum* (nightshade); *Dianella intermedium* (blueberry); *Haloragis procumbens*, 1 only; *Meliclytus ramiflorus* (mahoe), 2-3; *Myoporum laetum* (ngaio), 1 only.
- (2) seeds of: *Carex testacea*, a good deal; *Carex lucida*, a few; *Solanum nigrum*, a good deal; *Deyeuxia* sp. (grass), a few.
- (3) seeds of: *Carex testacea*; *Bromus mollis* (grass), a few.
- (4) seeds of: *Sicyos angulata* (native cucumber); *Solanum nigrum*, a few; *Coprosma rhamnoides*, 2 only; *Meliclytus ramiflorus*, a few. Some animal matter.

The analyses show that *Carex testacea*, still the most abundant element in the ground layer under the forest, continues to provide a large proportion of the food. Most of the other seeds found in the recent specimens could have been obtained, although only in a relatively few places, in 1946. The exceptions, representing additional sources of food supply since goats were removed, are *Dianella intermedium*, *Solanum nigrum* and *Sicyos angulata*, all extremely rare in 1946. As the specimens were obtained in different seasons, this may also be reflected in the analyses. However, the analyses suggest that the quail are able to feed on a much greater variety of vegetable food, and it seems probable that a more abundant total food supply is available than in 1946.

Harrier. *Circus approximans* Peale. A nest above Tasman Bay was occupied by a young bird which was fully fledged, and flew a short distance when approached closely. Remains of red-billed gulls and fluttering shearwaters were found at the nest, but no land birds. It is possible that the gulls and petrels had been picked up dead. A day later two adults and a young bird were seen flying about together over North West Bay. A pair, or single birds, were also seen on other occasions, one being observed flying slowly beneath the kanuka forest canopy in Tasman Valley.

Morepork. *Ninox novaeseelandiae* (Gm.). This species was observed on a number of occasions in different parts of the island, and several flying young still with a little down were seen.

In the course of field work a number of patches of feathers were noted on the ground, the total number recorded (P.C.B.) being 15, consisting of eight parakeets, four quail, two bellbirds and a fantail. All the birds appeared to have been completely plucked, and there was nothing left except the feathers. Considering the small area which could be examined, the total number of birds killed must have been large; two were found in the census quadrat during the work there. The birds were apparently killed at night, as several patches of feathers were found in the morning on tracks passed over on the previous day. Since there are no mammals on the island, it appeared that these birds had been killed by moreporks, and it seems that predation on small birds may be intensified during the period when young are being fed. Remains of bellbirds were found near the nests of moreporks during the visit in 1945 (Turbott and Buddle, 1948). The abundant lizards, as well as insects, also provide an important food supply, although they may be insufficient at this season.

Red-fronted parakeet. *Cyanoramphus novaezelandiae* (Sparrm.). A nest containing eight eggs was found on 30th December in a hollow, apparently formed by several old kingfishers' burrows, in the soft earth of a bank of the Tasman Stream. The eggs rested on a small amount of nesting material, mainly parakeet's feathers and a few twigs. The height of the nesting chamber was about nine inches, and the situation was about six feet above the stream bed. Adults which had been incubating, as shown by their frayed tail feathers, were also observed. Two parakeets observed at close quarters on the census quadrat were seen chewing off grass seed heads (*Danthonia semiannularis*) while perching on a low branch.

Long-tailed cuckoo. *Eudynamis taitensis* (Sparrm.). A single bird was seen twice in Tasman Valley.

Kingfisher. *Halcyon sancta* V. and H. In addition to those observed on the census area, pairs were noted near the camp and half way up the slopes of North West Bay. The latter were seen carrying food, once a cicada and on a second occasion a lizard. A nest containing five eggs was found on 30th December in the bank of the Tasman Stream.

Pipit. *Anthus novaeseelandiae* (Gm.). A nest with two eggs was found in the lower Tasman Valley on 7th January. There was also probably a nest near the depot, where a pipit was seen carrying food. On the bare cliff-top at the saddle above North West Bay this pair was observed feeding on small bees (see red-billed gull). Each bee was caught with the tip of the bill, beaten on the ground and then swallowed. Pipits up to eight in number were observed several times on the grassland and prostrate scrub of the south side of Tasman Valley, and elsewhere this species was seen mainly on bare patches or rocky outcrops in the forest, and on coastal rocks (see introduction, Part I).

Fantail. *Rhipidura fuliginosa* (Sparrm.). Adults and well-grown young, still keeping more or less to family parties, were seen in Castaway Valley, Tasman Valley and in the census area. The distinctive nature of the call note of the fantail on the island has been noted (Turbott and Buddle, 1948). The song was heard several times on the census quadrat, and the distinctive pitch and more eccentric rhythm were noted, as compared with the mainland form.

Bellbird. *Anthornis melanura obscura* Falla. Many young were observed, and a female was seen feeding two young birds on the census area. Although most of the adults were moulting, there was much song. The bellbird appeared to be feeding largely on insects, and one watched for some time was industriously searching in the head of a cabbage tree (*Cordyline australis*), apparently obtaining small caterpillars concealed in the leaf bases. A bellbird was seen catching a cicada during one of the census counts.

Chaffinch. *Fringilla coelebs* L. The full song was frequently heard, and a young bird apparently not long out of the nest was regularly heard calling in answer to the parents (see census). One nest (old) was found.

House sparrow. *Passer domesticus* (L.). Seen on the south side of the lower Tasman Valley, but nowhere else.

Song thrush. *Turdus ericetorum* Turt. Seen once.

Blackbird. *Turdus merula* L. Blackbirds were frequently heard singing strongly in the late afternoon. An old nest was found on the ground at the base of a low kanuka in Tasman Valley, concealed by overhanging sedges. Droppings found on a rock above Castaway Valley containing seeds of nightshade (*Solanum nigrum*) were probably those of this species; and one was seen holding a struggling cicada. An albino blackbird was seen in Tasman Valley.

Starling. *Sturnus vulgaris* L. The largest flock was estimated at 200 birds, and there was another flock of perhaps 50 in the Castaway Valley and quadrat areas (see under red-billed gull above). Single birds were seen feeding in the kanuka forest from time to time, moving quietly amongst the branches in contrast with the marked activity of birds forming the flocks. A young bird of the year in brown plumage was seen amongst the larger flock, but this consisted mainly of birds in adult plumage.

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Fig. 1. Regeneration of mixed coastal forest, of which young trees at present form an undergrowth. In foreground puka (*Meryta sinclairii*) about 9 feet high. Lower portion of census quadrat, January, 1953.

Fig. 2. Kanuka forest showing dense ground cover, mainly sedges. Upper portion of census quadrat, January, 1953.

Photos: E. G. Turbott.